

**TRANSMISSION LOSSES COST ALLOCATION IN RESTRICTED
ELECTRICITY MARKET ENVIRONMENT**

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ABSTRACT

During these recent decades, the restructuring system of electricity market has been taken places around the whole world. Due to the restructuring (deregulation), the electrical power system has been divided into three separates categories according to the function. First stage of power system is the generation companies (GENCOs), followed by transmission companies (TRANSCO) and distribution companies (DISCOs). The competitive environment will be handling by a non-profit entity, independent system operator (ISO) that functioning as the system securities that have to make sure that the power system continues to operate in a stable and economical manner. However, restructuring system can give effect during the energy transmission. One of the transmission issues is regarding the power losses. To overcome the losses, generators must generate more power. The issue regarding the transmission losses in deregulated system is how to allocate it to the user and charge them in fair ways as in for instance the pool trading model, it is hard to trace the power contribution and losses of each user in transmission line. In addition, the users didn't want to pay the losses, it means that the ISO have to responsible for the losses and it will be unfair to put the responsible to ISO alone. Therefore, in this project, the allocation of transmission losses and loss cost methods which are the pro-rata and proportional sharing method will be investigated. Comparison between those methods will be done in order to identify which types of method that reflect an efficient and fair way to distribute the cost of the transmission losses to the user. These chosen methods will be tested on IEEE bus system.

ABSTRAK

Mutakhir ini, sistem penstrukturan semula pasaran elektrik telah mula mengambil tempat di seluruh dunia. Dalam sistem penstrukturan semula, sistem kuasa elektrik telah dibahagikan kepada tiga kategori bergantung kepada fungsi masing masing. Tahap pertama ialah syarikat penjanaan (GENCO's) diikuti oleh syarikat penghantaran (TRANSCO's) dan diakhiri oleh syarikat pengagihan (DISCO's). Persekitaran yang penuh persaingan ini akan diurus oleh independent system operator (ISO) yang berfungsi sebagai sistem keselamatan bagi memastikan sistem kuasa terus beroperasi dalam keadaan stabil dan ekonomik. Walau bagaimanapun, sistem penstrukturan semula akan memberi kesan semasa proses penghantaran tenaga. Salah satu dari isu dalam proses penghantaran adalah berkenaan dengan kehilangan kuasa. Untuk mengatasi kehilangan ini, penjana kuasa perlu menjana lebih kuasa. Permasalahan berkaitan kehilangan kuasa semasa proses penghantaran adalah bagaimana cara untuk membahagi dengan samarata jumlah penggunaan dan juga kaedah untuk mengenakan bayaran terhadap pengguna dengan cara yang adil, contohnya seperti didalam model Pool Trading, proses untuk mengesan jumlah kuasa yang dijana dan kehilangan kuasa di setiap laluan penghantaran adalah rumit. Sebagai tambahan, jika pengguna tidak mahu membayar jumlah kehilangan kuasa tersebut, ISO terpaksa bertanggungjawab untuk membayarnya dan ini dikira sebagai tidak adil kepada ISO. Oleh itu, didalam projek ini, pembahagian jumlah kehilangan kuasa dan kaedah untuk mengira jumlah kehilangan kuasa iaitu kaedah pro-rata dan proportional sharing akan di kenal pasti. Perbandingan diantara kedua kaedah akan dilakukan bagi mengenal pasti kaedah yang boleh memberikan cara yang adil dan efisien untuk membahagikan kos bagi kehilangan kuasa untuk pengguna. Kaedah yang dipilih juga akan diuji pada IEEE standard bas sistem.

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CHAPTER 1

ELECTRICITY MARKET ENVIRONMENT

Chapter 1 consists of five important elements. Firstly is the introduction about the electricity market and the restructuring system. Secondly is about the problem statement of the project, which is the problem that needs to be addressed. In this project, the challenge is to investigate the transmission allocation method used to compensate the losses. Thirdly is about the objectives for this project. There are four objectives that must be achieved in this project. After that is the scope of project. In which there are three type of transmission losses allocation method that has been identified. Lastly is the outline for the whole project.

1.1 Project Overview

During these recent decades, the restructuring system of electricity market has been taken places around the whole world. In restructuring system, the restructuring model can be divided into four types which are pool trading, single buyer, bilateral contracts and hybrid model. For developing countries, the main issues have been a high demand growth coupled with inefficient system management and irrational tariff policies. In that condition, many utilities company have to restructure their power sector.

While in the developed countries the electricity is provided at lower prices and have offer consumer a greater choice to purchase economic energy. The changing system is to enhance a competition and to bring consumer a new choices and economic energy.

Some terms that must be understands in the electricity market is regulation and deregulation. Regulation means that the government has set down laws and rules that put limits on and define how a particular industry or company can operate. While in the other hand, deregulation means that the restructuring of the rules and economic incentives that governments set up to control and drive the electric power industry.

The main reason for regulation is because of regulation has offered a risk free way to finance the creation of electric industry. An establishment of electric industry will require larger capital for the infrastructure building. Second reason for regulation is it will legitimize the electric utility business. The regulation also gave electric utilities recognition and support from the government and the last reason is regulation will established a local monopoly.

A regulated electric industry has several characteristics which are monopoly franchise, obligation to serve, regulatory oversight, least-cost operation, regulated rates and assumed rate of return. Monopoly franchise means that within the service territory, the task to produce, move or sell the commercial electric power can only be done by local electric utility company. The electric utility company must provide every service that related not just the profitable work is the meaning of obligation to serve.

The regulatory oversight means that during business and operating practices, the utility company must obey the rules and guideline that have been prepared by government. A least-cost operation means that every utility must minimized their usage from the total overall revenue requirements. While regulated rates are the utility's rate that must be set in accordance with the government rules and guideline.

Lastly, if the utility company comply with all the standard and regulation that provided by the government, the utility is assured a fair return on its investment.

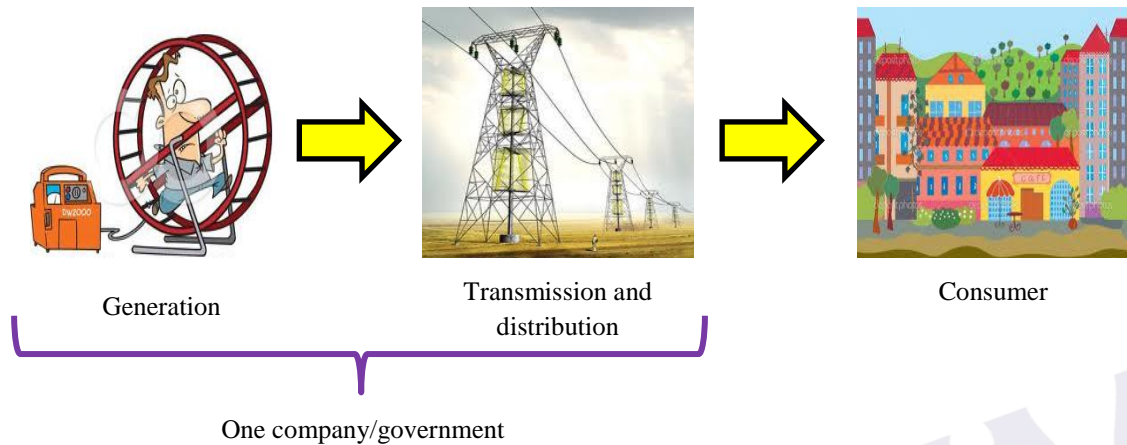


Figure 1.1: Regulated electric industry

Due to the restructuring (deregulation), the electrical power system has been divided into three separate categories according to the function. The different three functions have been conducted by three different companies. First stage of power system is the generation companies (GENCOs), followed by transmission companies (TRANSCOs) and distribution companies (DISCOs). GENCOs basically are electric power manufacturer. They own generation units and produce electric power, which they sell “at their site” in the same manner that a coal mine might sell coal in bulk at its railhead [11]. TRANSCOs are the company who provide facility to transmit the power in bulk quantities from the generation site to the demand site. The transmission process will get pay by the charging for transmission services. While GENCOs is a company that owns, operates and delivered electricity locally in the demand area.

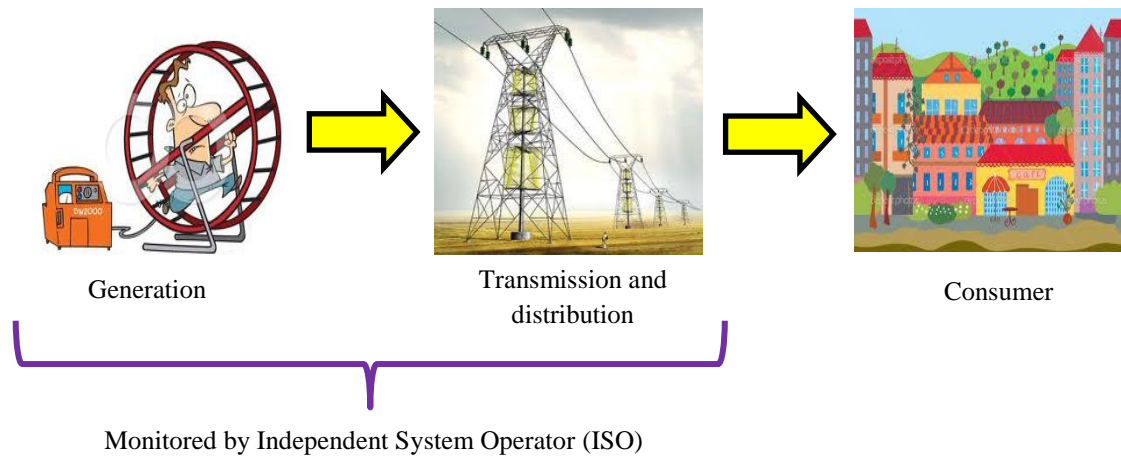


Figure 1.2: Deregulated electric industry

There are several reasons for deregulation. The reason can be concluded [6]:

- a. The need for regulation has changed
- b. Privatization
- c. Cost expected to drop
- d. Customer focus will improve
- e. Encourages innovation

The competitive environment will be handling by a non-profit entity, Independent System Operator (ISO). ISO functions as the system securities that have to make sure that the power system continues to operate in a stable and economical manner. The operator also should provide the power transportation services requested of it by buyers and sellers.

System operator must determine and post the prices for transmission usage, offer to reserve or sell usage, track, bill and settle with users and pass on revenues to transmission owners. The system operator must also make sure the quality of the services provides. The overall operations of system operator should obey economic efficiency and also it should have fairness and equity in its dealing and should not benefit only some parties in the system.

The restructured system has produce competition between all the suppliers and the generator. But restructuring system can give effect during the energy transmission. The transmission process will cause power losses. To overcome the losses, generators must generate more power. If the generators or consumers didn't want to pay the losses, it means that the ISO have to responsible for the losses. But it will be unfair to put the responsible to ISO. The allocation cost method is been study to make sure that the existence of power system is fulfilled. The power system's is built to make sure that it will comply under some circumstances which are [11]:

- a. It must do so economically, for cost is an important criterion in electric usage.
- b. It must do so reliably, because electric power is very close to a necessity in developed societies. Power availability on the order of 99.99% is expected in many parts of the world.
- c. It must deliver power safely. Electric power is a form of energy and left unchecked, like any energy source, can hurt people and destroy property.
- d. It must function well within de-regulated industry. Generally, this means limitations on the operation and pricing rather than on the design, but it is a consideration to keep in mind.

Thus, this project will investigate the cost allocation method in order to overcome the problem arise from the transmission losses.

1.2 Problem Statement

In the restructuring system, there are several problems arise to allocate the cost of transmission losses among the parties involved. One of the issues is allocating the transmission losses to the users and charging them in fair manners. There are many transmission losses cost allocation methods that had been proposed such as pro-rata and proportional sharing. Therefore, this project is to investigate those methods in order to allocate the transmission losses among the transmission user. In addition an efficient transmission losses cost allocation method will be identified.

1.3 Objectives

The objectives for this project are:

- a. To investigate and compare the existing transmission losses cost allocation methods.
- b. To test various types of transmission losses cost allocation methods on a small scale power system model and IEEE bus system.
- c. To determine the appropriate transmission losses cost allocation method that can distribute the loss charges fairly among transmission users.

1.4 Scope of project

This project only focused on the pool market model. The pool market model has been chose due to the complexity to trace the electricity flow. After that, the analysis about the transmission losses and several transmission losses cost allocation methods will be done which are pro-rata and proportional sharing method. This project also will be tested on IEEE bus system.

1.5 Report Outline

This report consists of five chapters. Chapter 1 is about the introduction of electricity market. In the introduction, the problem statement, objectives and scope have been explained. While in Chapter 2, all the literature about pool trading, transmission losses and transmission losses cost allocation method is summarizes. Next chapter will be providing with the methodology of this project. It consist the whole process in this project. Chapter 4 will describe about the result from the whole semester and Chapter 5 will be the conclusion and recommendations for the project.



CHAPTER 2

LITERATURE REVIEW

This chapter presents about the concept of pool trading in the electricity market environment. The effect of restructuring system will also be explained. Then it will followed by brief explanation about transmission losses and allocation method. The transmission losses can be divided into three types which are variable losses, fixed losses and non-technical losses. While the transmission losses cost allocation method are the pro-rata method, proportional sharing method and novel pricing method.

2.1 Overview of Pool Trading Model

Pool trading model market can be categorized into two which are:

- a. One sided pool: The generators side will submit the bids and their available supply capacity. These bids are ranked in order of increasing price. Meanwhile, the demand curve is predicted to be a vertical line at the value of the load forecast. The highest priced bid that intersects with the demand forecast will determines the market price, which is applied for the whole system.

- b. Two sided pool: In two sided pool, the consumers can submit offers specifying quantity and price and ranking these offers in decreasing order of price. The intersection of the supply and demand curve represents the market equilibrium.

In the pool trading model, all energy supply is controlled and coordinated by a single pool operator (Independent Market Operator). Because of the fact that there is no ideal cost allocation method, the method should have some properties to make sure the losses is calculated fairly. The properties are stated below [1]:

- a. To be consistent with the results of a power flow
- b. To depend on the amount of energy either produced or consumed
- c. To depend on the relative location in the transmission network
- d. To avoid volatility
- e. To provide appropriate economic marginal signals
- f. To be easy understand
- g. To be simple to implement

2.2 Overview of Transmission Losses

During the transmission, the electrical transfer to the distribution panel will generate power losses. To compensate the losses, generator site have to generate more and more power. This will make the generator site having losses in term of energy and cost to generate more power. In the competitive electricity market environment, no generators site will willing to take losses and generate more power. There three types of losses in the power system:

a. Variable losses

They are caused by the current flowing through the lines, cables and transformers of the network and are also called load losses, series losses, copper losses or transport-related losses. They are proportional to the resistance of the branch and to the square of the current in this branch.

$$L_{\text{variable}} = I^2 R \quad (2.1)$$

b. Fixed losses

Most of these losses are caused by hysteresis and eddy current losses in the iron core of the transformers. The rest is due to the corona effect in transmission lines. Fixed losses are proportional to the square of the voltage and independent of the power flows. However, since the voltage varies relatively little from its nominal value, as a first approximation, these losses can be treated as constant. They are also called no-load losses, shunt losses or iron losses.

c. Non-technical losses

The non-technical losses is the energy stolen from the power system.

Because of their quadratic dependence on the power flows, variable losses are much more significant during periods of peak load and typically much larger than fixed losses. Averaged over a whole year, in western European countries, 1% to 3 % of the energy produced is lost in the transmission system and 4% to 9% in the distribution system. Due to the fact, this project will only consider the variable losses.

2.3 Overview of Network Losses and Allocation Method

Basically, the total power generated is more compared to the total demand. This is due to the total power generated is sum of total demand and include with the total power losses.

The total power generated can be calculated based on Equation 2 below:

$$P_G = P_D + L, \quad P_G = \sum_{i=1}^{N_G} P_{Gi}, \quad P_D = \sum_{j=1}^{N_D} P_{Dj} \quad (2.2)$$

P_G = total active power generated

P_{Gi} = power output of generators of bus i

P_D = total active power demand

P_{Dj} = active power demanded by consumers of bus j

L = transmission power losses

N_G = number of generating buses

N_D = number of demand buses

To overcome the losses, there are two cost allocation method used which is pro rata and proportional sharing.

2.4 Allocation Cost Method Based on Country

Table 2.1 below show the cost allocation method used based on country [9]. There's many type of cost allocation method that been used around the world.

Table 2.1: Allocation cost method based on country

Countries and region	Electricity market model	Transmission power loss allocation method
England and Wales	Power pool market	Current: The average loss allocation method Plan: Regional average loss allocation method
Northern Ireland	Bilateral trading market & a single purchase of electricity	Average loss coefficient
Norway	Bilateral trading market & power pool market	Current: Regional marginal loss method Plan: Average locational marginal loss method loss coefficient
New Zealand	Bilateral trading market & power pool market	Real-time nodal pricing (dynamic node pricing)
Argentina	Bilateral trading market & power pool market	Dynamic node pricing
New England (U.S)	Bilateral trading market & power pool market	A slight increase loss coefficient for the bilateral trading market
New York (U.S)	Bilateral trading market & power pool market	Real-time generator and load nodes price
Ontario (U.S)	Bilateral trading market & power pool market	Average net loss method to consider turning real-time nodal pricing

2.5 Previous Study

Table 2.2 below shows the comparison of previous study done based on the cost allocation method used and the test done using bus system.

Table 2.2: Summarize of previous study on cost allocation method

Author	Title	Project Description
A.J Conejo, J.M. Arroyo, N. Alguacil	Transmission Loss Allocation: A Comparison of Different Practical Algorithms	Method used: <ul style="list-style-type: none"> - Pro-rata - Marginal allocation - Unsubsidized marginal allocation - Proportional sharing Case study on IEEE RTS
Anis Niza binti Ramani	Transmission Losses Allocation in Deregulation Electricity Market	Method used: <ul style="list-style-type: none"> - Pro-rata - Proportional sharing - Novel pricing Case study on IEEE standard 14 bus test system
P. Srinivasa Varma, V. Sankar	Transmission Cost Allocation With and Without Losses in Restructured Power System	Method used: <ul style="list-style-type: none"> - Postage stamp and power flow - Proportional sharing principle Case study on IEEE standard 24 bus test system
Baseem Khan, Ganga Agnihotri	A Novel Transmission Loss Allocation Method Based on Transmission Usage	Method used: <ul style="list-style-type: none"> - Nucleolus method Case study on IEEE standard 6 bus test system
Jing Dai, Yannick Phulpin, Vincent Rious, Damien Ernst	How Compatible is Perfect Competition with Transmission Loss Allocation Methods?	Method used: <ul style="list-style-type: none"> - Pro-rata - Proportional sharing - Equivalent bilateral exchange Case study on IEEE standard 2 bus test system
F.Ansyari, C.S.Özveren, D.King	Allocation of Transmission Losses Using Three Different Proportional Sharing Methods	Method used: <ul style="list-style-type: none"> - Pro-rata - Incremental marginal allocation - Proportional sharing Case study on IEEE standard 4 bus test system

Ahad Kazemi, Hooman Andami	A New Method for Transmission System Loss Allocation in Electric Power Markets	<p>Method used:</p> <ul style="list-style-type: none">- Pro-rata- Incremental transmission losses- Z-bus- Proportional sharing- Game theory- Equivalent networks- Transaction based method <p>Case study on IEEE RTS standard 24 bus system</p>
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CHAPTER 3

METHODOLOGY

Chapter 3 presents the methodology which is the whole process in this project. The whole process can be categorized in four steps as shown in block diagram in Figure 3.1 below.

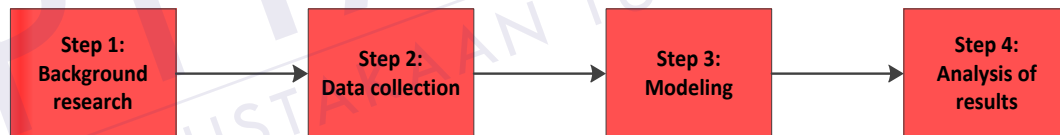


Figure 3.1 Project methodology

The first step is the background research where the information required for transmission losses allocation method is done. Then, the data collection of transmission losses allocation will be implemented using simple 2 bus system to enhance the understanding of the method. The process followed by implementing the allocation method using more complicated bus system. Lastly, the results obtained will be discussed and analyzed to compare with each method.

3.1 Transmission Losses Cost Allocation Method Methodology

3.1.1 Background Research

During the background research, all data about the transmission losses allocation method is been study. There are several transmission losses cost allocation method. After doing the background research for those method, the methods selected is Pro-Rata and Proportional Sharing. The aspect to study for both methods is the formula needed to calculate the losses, advantage, disadvantage and the allocation method properties.

a. Pro rata method

The first allocation cost method used is pro-rata method. Pro-rata is a classical method, which easy to implement and understand. It has been used so many years before the power system. The approach does not depend on the network and is unable to trace power flow. It can be characterized by the allocation of electric losses proportional to the power delivered by each load and each generator.

The pro-rata method advantage is it can allocate the losses equally to the particular loads. But the disadvantage is pro-rata method did not include the transmission lines length. Thus two identical loads located at different distances from the generators are treated. The transmission cost losses is charged to the consumers through a uniform pro rata charge which means that the same bid for each hour.

$$L_{Dj} = L \frac{P_{Dj}}{P_D} \quad (3.1)$$

P_D = total real power consumed

P_{Dj} = real power consumed by loads of bus j

L_{Dj} = losses allocated at demand j

Pro-rata method can be simplified in four steps:

1. Revenue with and without losses (RM)

$$\text{with losses} = \text{bid price} \times \text{gen. maximum capacity} \quad (3.2)$$

$$\text{without losses} = \text{bid price} \times (\text{gen maximum capacity} - \text{losses}) \quad (3.3)$$

2. Loss allocate to particular load

$$\text{loss allocate at node } i = \frac{\text{load at node } i}{\text{total load}} \times \text{total losses} \quad (3.4)$$

3. Loss cost to particular load

$$\text{loss cost} = \frac{\text{loss allocate at node } i}{\text{total losses}} \times \text{amount loss} \quad (3.5)$$

4. Total load charges towards particular load

$$\text{load charge at node } i = (\text{load at node } i \times \text{bid price}) + \text{loss cost} \quad (3.6)$$

b. Proportional sharing principle

Proportional sharing principle is based on a non-provable or disprovable theorem that assumes the inflow powers are proportionally shared between the outflows power at each network bus. It means that the nodal inflows are shared proportionally among nodal outflows. Sometimes it can also been called as flow-tracing scheme.

This method uses a topological approach to determine the contribution of individual generators or loads to every line flow based on the calculation of topological distribution factors. This method can deal with both dc-power flow and ac power flow and can be used to find contributions of both active and reactive power flows [5].

Based on Figure 3.2 below, there are 4 branches connected with node i where j and k are the inflow branches while m and l are the outflow branches.

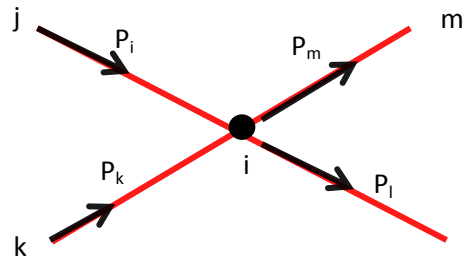


Figure 3.2 : Proportional sharing principle

$$P_{j-m} = \frac{P_j}{P_j + P_k} P_m$$

$$P_{k-m} = \frac{P_k}{P_j + P_k} P_m$$

$$P_{j-l} = \frac{P_j}{P_j + P_k} P_l$$

$$P_{k-l} = \frac{P_k}{P_j + P_k} P_l$$

$$P_{j-m} = \frac{P_j}{P_j + P_k} P_m$$

The formula tracing by gross flows to the loads from the generating sources are the same with upstream tracing algorithm. The unknown gross nodal power P_i^{gross} will be define as a total power flow through node i. The unknown gross nodal power defines must satisfies the Kirchoff's Current Law. P_i^{gross} will flow if the network was fed with the actual generation and no power lost in the network.

The power equations at node i considering the power inflows from upstream-looking algorithm is defined by:

$$P_i^{gross} = \sum_{j \in \alpha_i^{(u)}} |P_{i-j}^{gross}| + P_{Gi} \text{ for } i = 1, 2, \dots, n \quad (3.7)$$

P_i^{gross} = the nodal gross power flow through node i

P_{i-j}^{gross} = unknown gross flow in line i-j which would flow if no power lost.

$P_{i-j}^{gross} = P_{j-i}^{gross}$

$\alpha_i^{(u)}$ = the set of nodes supplying nodes i

P_{Gi} = the power generation in node i

By assuming the $|P_{i-j}^{gross}| = |P_{j-i}^{gross}|$ and the distribution of gross flows at any node is the same with the distribution of actual flows, $|P_{i-j}| = |P_{j-i}|$. The flow P_{i-j} will be replaced with $C_{j-i}P_j$ where $C_{j-i} = \frac{P_{j-i}}{P_j}$ which mean that Equation 2.7 can be written as:

$$P_i^{gross} - \sum_{j \in \alpha_i^{(u)}} \frac{|P_{j-i}|}{P_j} P_j^{gross} = P_{Gi} \quad (3.8)$$

Or can be replace in matrix form,

$$A_u P_{\text{gross}} = P_G \quad (3.9)$$

A_u can be calculated by using the properties shown below:

$$[A_u]_{i-j} = \begin{cases} 1 & \text{for } i = j \\ \frac{-|P_{j-i}|}{P_j} & \text{for } j \in \alpha_i^{(u)} \\ 0 & \text{otherwise} \end{cases}$$

A_u = upstream distribution matrix calculated from the actual flows

P_{gross} = unknown vector of gross nodal flows

P_G = vector of nodal generators

From Equation 2.9, after solving the A_u and P_{gross} value, the P_G value can be determined. Once the gross nodal flows have been determined, the gross line flows and gross demands can also be found using the proportional sharing principle. Equation 2.10 below show the value of gross flow in line i-j.

$$|P_{i-j}^{\text{gross}}| = \frac{|P_{i-j}^{\text{gross}}|}{P_i^{\text{gross}}} P_i^{\text{gross}} \quad (3.10)$$

$$\cong \frac{|P_{i-j}|}{P_i} \sum_{k=1}^n [A_u^{-1}]_{ik} P_{Gk} \quad \text{for all } j \in \alpha_i^{(d)}$$

The gross demand at node i can be calculated as

$$\begin{aligned} P_{Li}^{\text{gross}} &= \frac{P_{Li}^{\text{gross}}}{P_i^{\text{gross}}} P_i^{\text{gross}} \\ &\cong \frac{|P_{Li}|}{P_i} P_i^{\text{gross}} = \frac{P_{Li}}{P_i} \sum_{k=1}^n [A_u^{-1}]_{ij} P_{Gk} \end{aligned} \quad (3.11)$$

Equation 2.11 shows the load demand at a given node if a lossless network was fed with actual generation. Hence, the gross demand and actual demand differences can be obtained from Equation 2.12 below.

$$\Delta P_{Li} = P_{Li}^{\text{gross}} - P_{Li} \quad (3.12)$$

The differences between represent the loss which is attracted by power flowing from all the generators to a particular loads. In addition, the upstream-looking algorithm not only allows to determine the participation of each generator in satisfying a particular load demand. Upstream-looking algorithm also can divide the total transmission loss to individual loads in the network. This will prove the equality of Proportional Sharing Principle that will charge the losses among of each load.



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3.1.2 Data Collection

In this part, pro-rata and proportional sharing method have been study and tested on simple 2 bus system to analyze which method reflect an efficient way for allocating the losses.

3.1.3 Modeling

After successful been implemented on 2 bus system, both allocation methods are tested on 4 bus system, IEEE 9 bus system and IEEE 14 bus system. Power World Simulator software is been used to design the 4 bus system, IEEE 9 bus system and IEEE 14 bus system,. To model the bus system, the resistance and reactance of the transmission line represent the length of transmission line. The resistance and reactance value is obtained from the IEEE datasheet. The Power World Simulator software also can calculate the line flow between the sending end and receiving end of the power flow. The line losses for each line flow also can be obtained from the line flow.

3.1.4 Analysis of Results

Finally, the result will be analyzed to see the effect in terms of cost paid by the load. The analysis that had been done also can locate the fairness and equality in the losses distribution among the particular load. The analysis done will be in term of cost paid from particular load to overcome the losses. After the analysis is done, several recommendations are propose to overcome the weakness of the transmission losses allocation method.

3.2 Overall Process

Based on Figure 3.3, the overall process for Master Project 1 is shown. According to the flowchart, firstly, the deregulated electricity market consists of single buyer model, pool trading model, hybrid model and the bilateral contract model.

The pool trading model is chosen in this project due to the complexity for tracing the power flow. Next step is to determine the transmission cost losses in the transmission line. The losses are divided in three which are variable losses, fixed losses and non-technical losses. Then, the cost allocation methods are identified. Cost allocation methods used in this project are pro-rata method and proportional sharing principle method. After that, the case study using 2 bus system is done by implementing pro-rata method to use as preliminary results. The sources for the information are obtained from IEEE proceeding papers, books, project thesis and etc.

While Figure 3.4 shows the overall process for Master Project 2. Firstly, the proportional sharing principle method will be tested on the simple 2 bus system. After that, Power World Simulator software are used to modeled the 4 bus system, IEEE 9 bus system network and IEEE 14 bus system network. Both allocation methods are implemented on the bus system. After the result was obtained, data will be analyzed to evaluate both methods. The fairness in allocating the transmission losses between particular loads is the main objectives for this project.

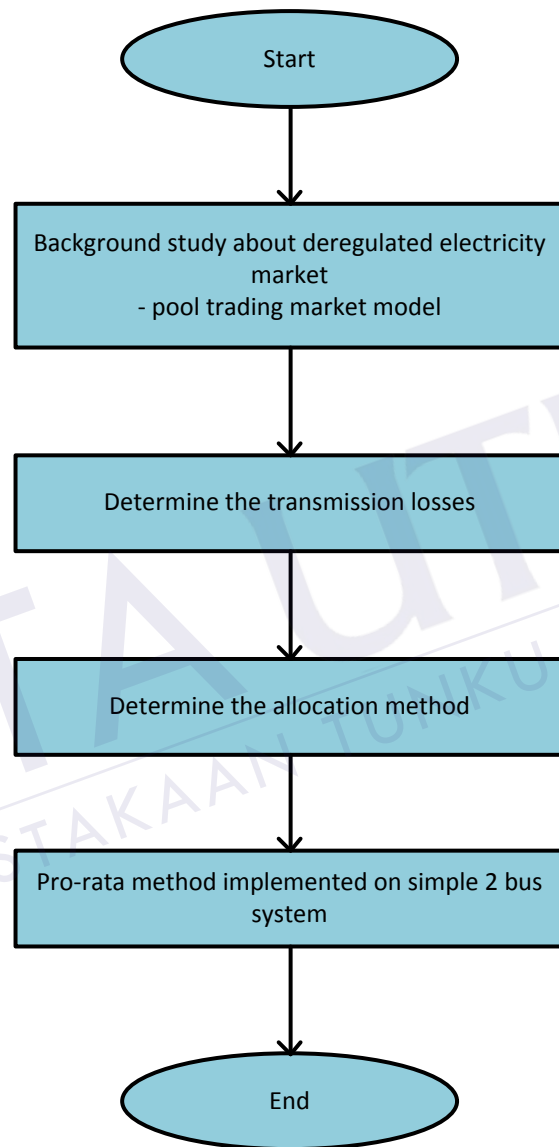


Figure 3.3: Flowchart for master project 1

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